On the physical nature of light-pulse atom interference.

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Abstract

It is proposed to use the light-pulse atom interferometry for experimental study of some properties of quantum memory.

Light-pulse atom interferometry is a method for high precision gravity measurements, fundamental physical constants, and tool to probe fundamental physics [1]. However, the phenomenon itself of light-pulse atom interference (as usual today in quantum physics) practically does not have any physical explanation. It is said that the first laser pulse creates a superposition of quantum states. Later, these quantum states interfere in the same way as in the Mach-Zehnder interferometer. And this is all the “physical” explanation.

It should be noted that the superposition of quantum states and entanglement are more mathematical than physical concepts. We believe that their physical equivalent is the memory of the quantum system about its initial state [2]. This memory is a consequence (or reason) of nonequivalence of forward and reversed processes in quantum physics. An extremely large and sharp differential cross-section of reversed transitions is the real physical base of nonlinear optics. The same is, probably, the basis of the light-pulse atom interference [3]. Here we propose to use light-pulse atom interference to study some properties of this quantum memory.

The most popular in atomic interferometry is the use of the scheme $\pi / 2$ - π - $\pi / 2$ with Raman transitions [4]. The first laser impulse transfers a part of atoms to other quantum state. After a time T, the second pulse inverts the population of these levels. Through time of T the third impulse follows. The interference pattern is observed by changing the phase of the second or third pulses.

What will happen if the phase of only the first pulse is changed? In working order, such experiments, obviously, were carried out, but in the published works they are absent. The reason, probably, is that the scientists do not understand what information is contained in these results. However, these results can give the information about whether the memory of the quantum system about its initial state is preserved or degraded. Here you can use a number of successive pulses of different types (for example $\pi / 2$ - π …(N)… π - $\pi / 2$) [5-7].

So, we hope that this message will stimulate our scientists to eliminate this white spot in the field of light-pulse atom interferometry.

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